

ABSTRACT

An apparatus and method to enhance oxygen delivery to tissue encapsulated in an immunobarrier device. In one embodiment, *in situ* electrochemical oxygen generation by electrolysis of water into oxygen and hydrogen supplies oxygen to the tissue. In one embodiment a thin, multilayer sheet electrolyzer is enclosed in silicone rubber membranes permeable to gas and water vapor but not liquids. The anode side of the electrolyzer is in contact with one face of the device. Water vapor diffuses into the electrolyzer, decomposes at the anode, and oxygen diffuses back through the membrane to the implanted tissue, thus providing a continuous supply of water, continuous diffusion of O₂ and H₂ out of the electrolyzer, and exclusion of biological components that might contaminate the electrolyzer.

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Table 1. Values of important parameters in analyzed experiments

Parameters	Experiments								
	7a	7a	7c	7d	7f	9a	9b	9g	9h
Figure Number									
Culture Time, t (d)	0	0	2	2	6	2	2	3	3
Oxygen Flux, N (mol/cm ² ·s x 10 ¹⁰)	0 ^a	3.7 ^a	0	3.7	3.7	0	0.50	0	0.70
Tissue Thickness, L (μm)	40	40	50	70	100	30	25	25	75
Tissue Volume Fraction, 1 - ε	0.52	0.52	0.53	0.69	0.60	0.74	0.78	0.76	0.70
Oxygen Consumption Rate, V (mol/cm ³ ·s x 10 ⁸)	1.4	1.4	1.5	1.9	1.7	2.0	2.1	2.1	1.9
Oxygen Permeability, Dα (mol/cm·mmHg·s x 10 ¹⁴)	2.2	2.2	2.1	1.8	2.0	1.7	1.6	1.7	1.8
Tissue Thickness Supportable from Electrolyzer, L _e (μm)	0	250	0	190	220	0	23	0	37
Tissue Thickness Supportable from Medium, L _m (μm)	140	140	140	110	130	110	100	100	110
Interface P at x = L/2, P _{Se} (mmHg)	116	313	108	340	356	115	144	120	115
Interface P at x = - L/2, P _{Sm} (mmHg)	122	250	116	224	212	121	141 ^b	124	116
Minimum P, P _{min} (mmHg)	---	---	---	---	---	---	141 ^b	---	108

For all examples, $P_m = 142$ mm Hg, $R_{ext} = 3.5 \times 10^{11}$ mm Hg/(mol/cm²·s), $\delta = 50$, $L_{M2} = 15$, and $L_{M1} = 30$ μm, $(D\alpha)_{med} = 3.5$, $(D\alpha)_{M2} = 2.8$, and $(D\alpha)_{M1} = 2.0 \times 10^{-14}$ mol/cm·mmHg·s, $D_{med} = 2.8 \times 10^{-5}$ cm²/s, $\alpha_{med} = 1.3 \times 10^{-9}$ mol/cm³·mmHg, $V_{max} = 2.76 \times 10^{-8}$ mol/cm³·s, $P_c = 0.1$ mm Hg, and $K_m = 0.44$ mm Hg. Calculations were carried out with three or more digits, but all parameter results, except for partial pressures, were rounded to two.

^a The results at t = 0 correspond to the hypothetical oxygen profiles in the absence and presence of an imposed oxygen flux, respectively.

^b $P_{Sm} - P_{min} \ll 0.5$ mm Hg